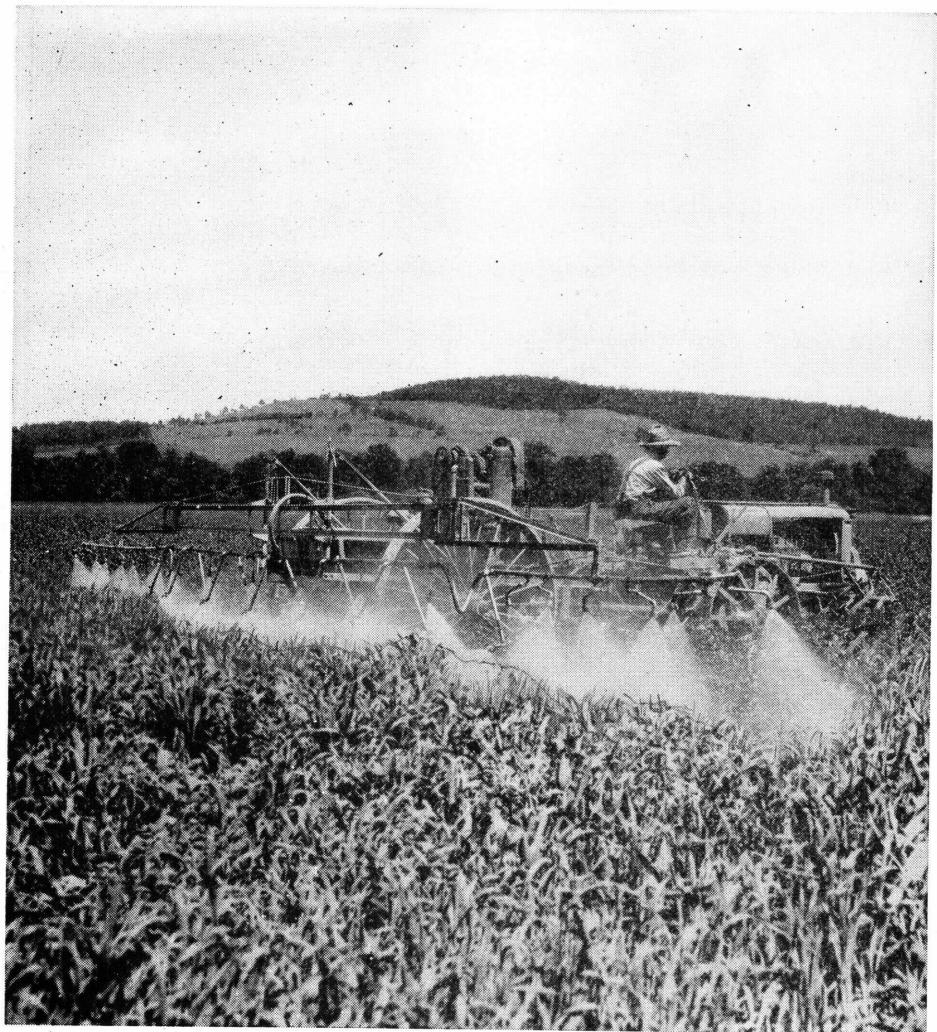


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USING 2,4-D SAFELY



FARMERS'
BULLETIN
No. 2005

U.S. DEPARTMENT OF AGRICULTURE

KNOW THE FACTS ABOUT 2,4-D BEFORE USING IT

2,4-D is a chemical that will work for you or against you, depending on how you use it. It will kill or damage most broadleaved plants—valuable crops as well as weeds. Properly used, it can put dollars into your pockets. Improperly used, it can cost you money. This bulletin is designed to give you facts you should know about 2,4-D to use it safely.

Do not dust from an airplane.—2,4-D dusted from an airplane may drift for miles, killing or damaging susceptible crops on a neighbor's farm as well as on your own.

Use no more than the minimum need.—2,4-D is potent. An overdose may seriously injure even tolerant crops.

Use wisely—follow directions.—2,4-D is not a cure-all. Study the label on the container. Measure quantities accurately. Follow directions closely.

Check equipment carefully.—Be sure your equipment is right and that it does not leak. Proper nozzles, accurately adjusted, are the key to safe, thorough spraying.

Safeguard sensitive plants.—Flowers, vegetables, clovers, cotton, and other crops (see list on p. 4) are extremely sensitive. Beware of wind drifting dust or spray to nearby plants. Fumes of some types of 2,4-D also may do damage.

Apply at the right time.—2,4-D is most effective when plants are in active growth. Do not apply dilute spray solutions when the vegetation is wet with rain or dew. Avoid windy days for dusting and spraying.

Use separate sprayer for 2,4-D.—Minute quantities of 2,4-D left in a sprayer later used for insecticides will damage sensitive plants. It is safer, more convenient, and more practical to have a separate sprayer. If separate equipment is impractical clean the sprayer thoroughly with ammonia or activated charcoal.

Keep posted on new information.—2,4-D is so new that some facts about it are not yet known. Research is continuing. For the latest information consult your county agent or write to your State agricultural college or to the United States Department of Agriculture, Washington 25, D. C.

USING 2,4-D SAFELY

Prepared by L. S. EVANS, agronomist, Division of Cereal Crops and Diseases, J. W. MITCHELL, physiologist, Division of Fruit and Vegetable Crops and Diseases, and R. W. HEINEN, information specialist, Division of Information, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration

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DISCOVERY of 2,4-D has brought about a completely new and revolutionary concept of weed control. In the short period since 1945 it has become the most widely used chemical weed killer in the United States. Commercial sales in 1948 are estimated at more than 8 million pounds. But 2,4-D *can kill crops* as well as weeds. An understanding of this new substance is essential to effective and safe use.

WHAT IT IS

A group of chemicals was discovered about 1935 that could be used to modify in some ways the growth of plants. At first they were thought of as plant-growth stimulants, and attention was directed toward using them for such purposes as to stimulate the rooting of cuttings, to inhibit shoot and leaf growth of nursery plants, and to prevent the dropping of fruits. It was soon found that some plants were injured and others killed when large quantities were used.

2,4-D is the abbreviation for the closely related chemical compounds now commonly used for killing weeds. Originally 2,4-D meant one substance known to chemists as 2,4-dichlorophenoxy-acetic acid. The abbreviation now used designates a number of compounds that are derived from this acid. As weed killers they are seldom sold in pure form. Instead they are usually mixed with other chemicals to increase their solubility, or with a carrier such as oil, and are sold as a powder or liquid ready to mix with water.

2,4-D was first used as a plant-growth regulator in 1942. It was extremely potent. Initial tests conducted by scientists of the Department of Agriculture with weeds revealed that 2,4-D could be used to kill plants selectively—it killed some but had very little effect on others. Intensified research in the Department and elsewhere was directed toward its early development as a

weed killer. Commercial distribution began in 1945. Today 2,4-D is used extensively to control weeds on farms and ranches and around homes. Research is being continued by the Department, by State agricultural experiment stations, and by other organizations.

2,4-D IS POTENT

One minute drop of pure 2,4-D, smaller than a flyspeck, is enough to affect the growth of sensitive plant seedlings. In most instances less than 1 pound of the chemical will control the weeds on an acre of cropland. When mixing 2,4-D, measure accurately to avoid overdosing. Measuring utensils should be cleaned or set aside for exclusive use with 2,4-D. *Be certain that even a minute quantity does not come in contact with valuable crop plants that are sensitive to it.* Tomato, bean, squash, and other sensitive garden plants may be injured if 2,4-D is applied directly to the soil around them—if planted in soil containing injurious quantities they may never come up.

HOW 2,4-D KILLS PLANTS

2,4-D is a plant stimulant—it speeds up respiration, digestion of plant foods, and use of reserve food materials. When it is applied in relatively large quantities, some of the growth processes may be stimulated to excess and the plant eventually dies. Death is due at least in part to the loss of reserve foods and to the activity of organisms that prey upon the weakened plant.

Most plants absorb 2,4-D rapidly. It will penetrate any part of a succulent plant—roots, stem, leaves, flowers, or bud. Once inside, the chemical moves rapidly. It apparently accumulates most readily in such fast-growing parts as buds and new roots.

Small quantities of 2,4-D stimulate the growth of new cells in some parts of the plant, deforming it. The veins of young leaves may become enlarged and flattened, and the leaves develop as long narrow strips with curled edges. Even a little 2,4-D may cause stems of succulent plants to grow more rapidly on one side than on the other, giving the plant a bent or wilted appearance and weakening it. Larger quantities stimulate to a marked degree some of the growth functions, such as respiration and digestion. It causes the plant to use up reserve starch. Under warm moist conditions, weakened plants become susceptible to attacks of soil-borne organisms and these cause the roots and lower stems to rot away.

FORMS

There are various forms of 2,4-D and each has different characteristics. Several, including the esters and the sodium, morpholine, amine, and ammonium salts, are commonly used for killing weeds. These salts are soluble in water and can be sold as a powder, with directions for making a spray mixture. Salt-type 2,4-D

can be applied most readily as liquid sprays, but dust forms are sold in handy applicator cans for use around the home. The ester types most commonly used are the butyl and isopropyl esters. They are liquids, mix readily with oil, and are generally sold as oil emulsions to be diluted with water for spraying.

VAPORS FROM 2,4-D

Relatively pure salt and acid forms of 2,4-D do not ordinarily give off enough vapor to affect plant growth. Ester forms, however, do, especially when the temperature is high. The ester forms should not be sprayed on weeds growing near sensitive plants. Cotton and tomatoes, for example, may be injured if a light wind carries the vapor from the treated area. Within an enclosure, such as a greenhouse, ester vapors have been known to damage sensitive vegetables several hundred feet away.

EFFECT ON WEEDS AND CROPS

2,4-D will kill most species of *broadleaved annual weeds*. Many of them are highly sensitive to 2,4-D and kill easily. Others are only moderately sensitive, but can be killed. Only a few species can withstand repeated applications of the chemical. (See list on p. 5.)

Biennial and perennial weeds (plants with roots that live more than 1 year) vary widely in their reaction to 2,4-D. A few perennials, including dandelion and plantain, can be killed with one treatment. Curly dock and other weeds with taproots are harder to kill. 2,4-D usually kills the foliage on perennials that have creeping roots, such as bindweed and Canada thistle, but repeated spraying of the new growth may be needed to kill all the roots. Detailed control directions can be obtained from a county agent, the State agricultural college, or the United States Department of Agriculture.

2,4-D sprayed on the leaves will kill the foliage on many species of *woody vines, shrubs, and trees* and on some the young woody tissue. A few species will die back to the ground, and the roots will be damaged. Woody plants can sometimes be killed by cutting the stems close to the ground and applying concentrated mixtures of 2,4-D to the fresh cut; it is generally best first to mow them and then spray the new growth with 2,4-D when the sprouts are 12 to 18 inches high.

The various *crop plants* react differently to 2,4-D, just as do weeds. Grasses are generally resistant, and broadleaved plants usually susceptible. Garden vegetables and flowers, almost without exception, are highly sensitive, and no plant is entirely immune. Even crop plants considered tolerant, especially young plants, may be injured severely by an overdose. Since grasses generally are highly resistant, weeds can be killed or controlled with 2,4-D spray without injury to lawns, pastures, small grain, and cornfields.

The effect of 2,4-D on crop plants is governed by the type used, the stage and vigor of plant growth, and differences in susceptibility within species. Seedlings of some plants, as annual sunflower and cocklebur, are so sensitive that all can be killed on an acre of ground with as little as a quarter of a pound of 2,4-D acid. As they approach maturity, killing is more difficult. Different corn hybrids have been found to vary from susceptible to resistant. Flax is generally sensitive, but the range of reaction between commercial varieties is wide. There are differences in susceptibility within species of field bindweed, Canada thistle, and other weeds. Resistant plants and plants treated during an inactive stage of growth react more readily to the ester forms of 2,4-D.

The dosage for spraying weeds in growing crops depends on what the crops will stand. A compromise between crop injury and effective weed control may have to do. Weeds can sometimes be controlled satisfactorily without being killed. Those that are stunted offer less competition with crop plants for moisture and food. Given a chance to get ahead, some crops will suppress the weeds.

The dust or vapor from 2,4-D has been said to damage the viability of *seeds, bulbs, and roots* stored in the same room, but

2,4-D will kill—	2,4-D can injure—	2,4-D does not affect—
Alder	Lilac	Arborvitae
Alfalfa	Marigold	Ash
Aspen	Nasturtium	Beech
Beans	Pepper	Blackberry
Birch	Poplar	Dogwood
Black walnut	Rhododendron	Evergreens, needle-leaved
Cantaloup	Roses	Grasses, practically all except
Carrot	Snapdragon	Bentgrass
Chrysanthemum	Soybean	Buffalo grass
Clovers	Spinach	Hawthorn (thorn apple)
Cotton	Squash	Hickory
Cottonwood	Sugar beet	Honeylocust
Cowpea	Sumac	Juniper
Easter lily	Sweetclover	Oak
Eggplant	Tamarix	Pine
Elderberry	Tomato	Redcedar
Field pea	Vetches	Timothy
Garden beet	Virginia creeper	
Garden pea	Watermelon	
Grape	Zinnia	
Hibiscus		
Lespedeza		

TABLE 1.—Effect of 2,4-D on various cultivated plants

[Column "2,4-D will kill" lists plants readily destroyed, at least in early growth stages. Column "2,4-D can injure" lists plants that can withstand a limited quantity. Susceptible weeds in these crops can be killed or controlled without damage to the crop when correct quantities are properly applied. Seedlings of plants under column "2,4-D does not affect" may be injured.]

the evidence is not conclusive. For the present it would be wise to keep 2,4-D isolated from any living plant material.

The classification of plants according to sensitivity to 2,4-D is shown in the lists in tables 1 and 2. Though based on widespread tests, the classification is subject to change, since local conditions may affect the sensitivity of certain plants.

2,4-D will kill most weeds, especially when they are young and succulent. Some weeds are difficult to kill and must be treated more than once. Others cannot be killed with 2,4-D. Listed in table 2 are those weeds that, according to present information, are difficult or impossible to kill. So far as is now known, weeds not listed can usually be killed with 2,4-D.

METHODS OF APPLYING

A dilute spray of 2,4-D is usually applied to plants. Any type of pressure spraying equipment can be used that will cover the leaves uniformly, with a minimum of runoff or wind drift—household spray guns, knapsack sprayers, power sprayers, or

2,4-D can control—	2,4-D does not affect—
Alligatorweed	Knotweed
Arrowhead lily	Lambsquarters
Barberry	Marestail
Bedstraw	Poison-ivy
Blue lettuce	Pokeweed
Buckbrush	Poverty weed
Bur ragweed	Prickly lettuce
Buttercups	Russian-thistle
Canada thistle	Sheep sorrel
Carpetweed	Shepherds-purse
Cattail	Smartweeds
Chickweeds	Spurges, including leafy spurge
Curly indigo	Teasel
Docks	Texas blueweed
Dodders	Tule
Dogbane	Wild buckwheat
Dogfennel (mayweed)	Wild carrot
Elderberry	Wild garlic
Field bindweed	Wild gourd
Fleabanes	Wild onion
Goatsbeard	Yarrow
Goldenrods	
Horsetail	
	Alkali mallow
	Beardtongue
	Bittersweet
	Buffalo-bur
	Cactus
	Catchfly
	Cockle
	Evergreens, needle-leaved
	Ferns
	Goutweed
	Grasses, practically all
	Groundcherry
	Hornsetacles
	Milkweeds
	Mullein
	Nightshades
	Oxeye daisy
	Pricklypear
	Purslane
	Ragwort
	Russian knapweed
	Swamp smartweed (kelp)
	Toadflax
	Violets
	Wild rose (except Cherokee)
	Wild strawberry
	Woodsorrel

TABLE 2.—Effect of 2,4-D on various weeds

[Column "2,4-D can control" lists weeds that often require several applications. Foliage may be partly or completely killed at early or rapid-growth stages. Roots of weeds listed in this column that live more than 1 year are seldom killed except by repeated treatments. Column "2,4-D does not affect" lists weeds that usually cannot be economically controlled.]

airplane spraying attachments. Best results are obtained with pressures between 30 and 100 pounds per square inch. Higher pressures not only are not needed but are wasteful and increase the danger from wind drift.

Numerous types of sprayers have been developed for field use, and many units are manufactured for quick attachment to ordinary farm tractors. They are small and relatively inexpensive and harness the tractor power for pump operation. Booms 10 to 30 feet long can be attached for selective spraying of field crops, and special adjustable booms are made for roadside and fence-row spraying. Hand guns are available for spot treatment of small patches.

Most modern units are equipped for low-volume spraying—2 to 10 gallons of spray solution per acre. For uniform spraying the proper nozzles must be used, especially with low-volume equipment. Fan-type nozzles are better than cone-type ones. Low-volume nozzle assemblies are available from most dealers and manufacturers, as are also such performance data as discharge rate, angle of spray, rated pressures, and recommended nozzle spacing.

Follow directions closely. A faulty discharge or a miscalculation of application rate can result in an overdose and seriously injure crops. A solution too weak may give a poor weed kill.

Line screens and nozzle screens will help reduce plugging of nozzle openings. The tank and spraying system must be clean and free from sediment for low-volume spraying. The 2,4-D products used should be completely soluble or form an emulsion with water that leaves no sediment or residue to clog the nozzles. Equipment should be carefully checked to make certain that the rate of delivery is the same as calculated. When possible, check the type of field where spraying will be done. The spray discharge can be adjusted by changing the size of the opening, by varying the forward speed of the equipment, or by adjusting the pump pressure.

AIRPLANE SPRAYING

Applying 2,4-D sprays by airplane creates special problems. Without a skilled experienced operator it is hard to distribute the chemical evenly. Areas might be skipped or treated twice, and wind might drift the spray a long distance. Airplane spraying is especially hazardous in areas where cotton or similar highly sensitive crops are grown.

Airplanes can be used to spray large areas, particularly in localities where no susceptible crop plants are grown. Spraying from the air is quick and economical. It can be done when the ground is wet and after small-grain crops have headed.

Danger of spray drift can be minimized by using leakproof equipment and providing check valves on the discharge mechanism for positive cut-off to prevent dribble. Plant spraying is best done during the morning and evening hours, when air movement is

at a minimum. The spray discharged from aircraft should be at the lowest possible safe flying elevation. When aircraft was operated at a 20-foot altitude with a cross wind of 5 to 7 miles per hour, spray particles drifted 1,350 feet, more than a quarter of a mile. At a 10-foot altitude under similar conditions the drift was reduced to 550 feet.

2,4-D dusts should not be applied by airplane if there are sensitive crops within several miles of the treated area. Wind may drift the dust many miles. The dispersion of 2,4-D dust from airplanes is controlled by regulations of the Civil Aeronautics Administration.

CLEANING SPRAYING EQUIPMENT

Though small-scale users find it safer, more convenient, and more practical to keep a separate sprayer for 2,4-D, it is often impractical to set aside large field equipment for such exclusive use. The equipment used for measuring and spraying 2,4-D must be thoroughly cleaned before being used on susceptible field, garden, or ornamental plants. Even a small residue of 2,4-D in a sprayer is potent enough to damage sensitive plants.

2,4-D can usually be cleaned from sprayers with a solution of household ammonia or a suspension of activated charcoal (carbon). It is practically impossible to remove 2,4-D from wooden tanks. To use the ammonia solution, rinse the sprayer thoroughly with clean water; prepare a 1-percent solution of household ammonia (2 teaspoonfuls per quart of water); fill the sprayer; leave the solution in the spray tank, booms, and hoses for 12 to 24 hours; then remove and rinse equipment thoroughly with clean water.

Cleaning with activated charcoal, which is available commercially, is much faster but more expensive. 2,4-D usually can be removed by rinsing the sprayer for about 2 minutes with a 1-percent suspension of activated charcoal followed by a rinse of clean water.

Neither method is always completely effective. To check the sprayer, fill with water, then spray seedlings of a sensitive test plant, such as bean or tomato, or a sensitive weed. If the plant is not affected within 1 or 2 days the equipment is safe for further use.

PROTECTION OF VALUABLE PLANTS FROM INJURY

For selective spraying of corn and other row crops adjust the spray equipment so that most of the 2,4-D is deposited on the weeds below the crop leaves. Only with the greatest care should 2,4-D sprays be used close to flowers, shrubbery, vegetables, or other valuable plants. Spray on days when there is little or no wind. Valuable plants can be partially protected with shields made of heavy paper, canvas, oilcloth, light wood, or metal.

Slight injury from 2,4-D can in most instances be first detected in the leaves of the plant, though it may not appear until 1 or 2

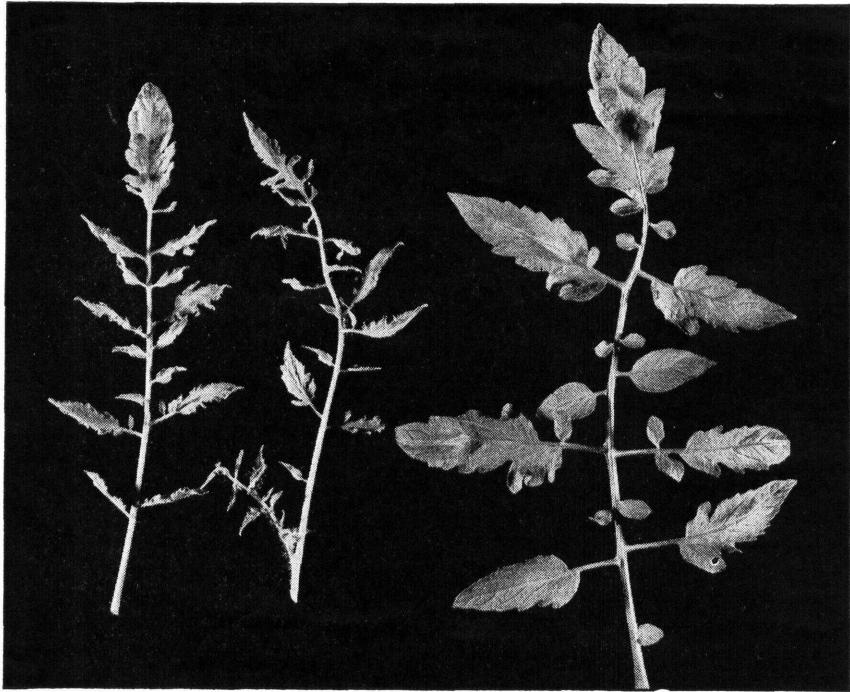


Figure 1.—Tomato leaves on left received drift from 2,4-D spray; leaf at right is normal.

weeks after the chemical has been applied. Slight injury deforms the very young leaves (fig. 1). After the leaves have grown out the symptoms become apparent, but in some cases the plant may outgrow them.

Severe 2,4-D injury to plants is usually apparent within a few days. Leaves become curled and the stems twisted. Plant growth may be checked, and after a week to 10 days the leaves may become discolored. Nothing can be done to save plants severely injured accidentally—once 2,4-D is on the plant it is too late. The chemical is rapidly absorbed by plant tissue. Even with a killing dose, however, the plant may not die for 2 or 3 weeks.

Valuable ornamental or crop plants injured accidentally by 2,4-D should not be destroyed until it is certain that the dosage was sufficient to seriously damage or kill them. Tomato and bean plants with two or three leaves deformed from slight injury have later recovered and produced an abundant crop. When severe symptoms are apparent—twisted stems and deformed leaves (fig. 2)—it is usually necessary to discard the plant.

To minimize the danger of 2,4-D damage to nearby valuable plants, observe one or more of the following precautions:

1. Use dilute sprays of sodium or amine salts.

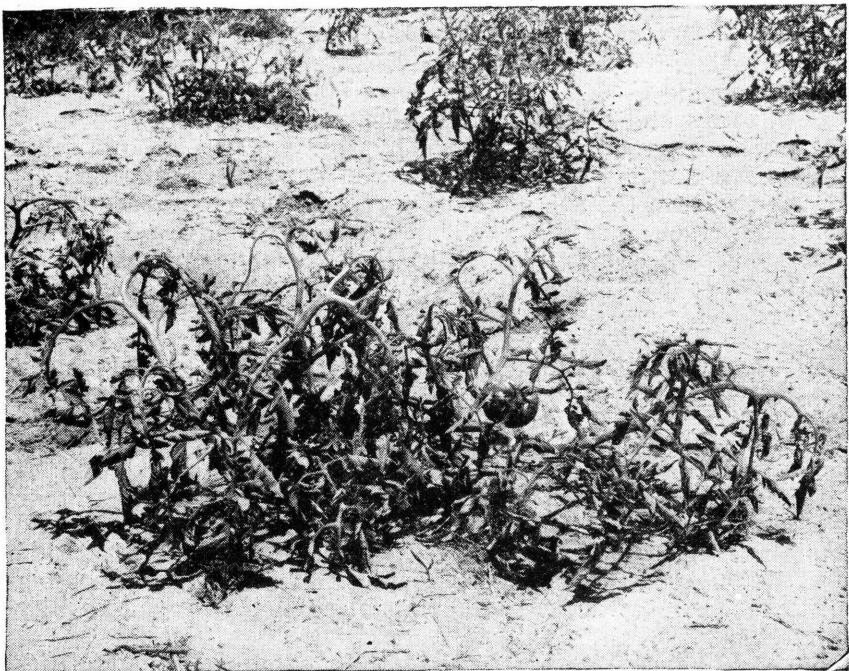


Figure 2.—Some crop plants are especially sensitive to 2,4-D: Tomato plant 5 days after an application of 0.03 percent 2,4-D spray (only one-third the strength of standard weed-killing mixtures).

2. Use the lowest pressure and nozzle capacity possible for efficient spraying.
3. Use the smallest possible dosage consistent with effective weed control.
4. Spray downwind of sensitive crops.
5. Spray at the time of year when the susceptible plants are in their least sensitive stage.
6. During and immediately following spraying cover susceptible shrubs and ornamental plants with bags (cement or fertilizer) made of treated paper or with other protective materials.

These precautions are not entirely foolproof. If they cannot be followed, do not use 2,4-D weed killers near valuable sensitive plants.

EFFECT OF 2,4-D IN THE SOIL

Under field conditions 2,4-D sprayed directly on the ground remains in the soil for periods of 2 or 3 weeks to 3 or 4 months. It stays longer in heavy than in light soils and longer in cool dry soils than in those that are warm and moist. Permanent soil contamination is unlikely. With normal rainfall and temperatures,

many crops can be planted safely on most soils about 30 days after a 2,4-D treatment. Seeding of legumes, vegetables, and other broadleaved crops in relatively dry regions and in cool weather should be delayed for at least 60 days.

Both grass and broadleaved weeds can be controlled for several weeks in crops such as corn by spraying the ground with 2,4-D after planting but before the crop comes up. Many factors, however, govern the success of this type of pre-emergence treatment, and much remains to be learned about them. Until they are understood it is difficult to predict the success of pre-emergence treatment. It may kill crops as well as weeds under some conditions.

EFFECT OF 2,4-D ON ANIMALS AND MAN

All available evidence shows 2,4-D to be harmless to animals and man. Cattle, sheep, and horses showed no ill effects after grazing on sprayed vegetation. A cow was fed more than 1 pound of 2,4-D during a 6-week period with no ill effect on health, appetite, or milk flow, and no 2,4-D could be detected in the milk. Certain plants may have a peculiar attraction for livestock when sprayed with the chemical. Some ill effects may be expected from spraying poisonous plants with 2,4-D and thus increasing their palatability to livestock.

Several persons have experimentally eaten small quantities of 2,4-D over a period without ill effect, and no authentic instance of human poisoning has been reported. In an extremely rare case a person having a peculiar sensitivity to various phenol compounds may find 2,4-D somewhat disagreeable. If concentrated solutions are accidentally spilled on the skin, wash it thoroughly with soap and water. Health authorities say that impurities in mixtures containing 2,4-D might prove harmful.

FURTHER RESEARCH NEEDED

Much still remains to be learned about 2,4-D and how it reacts on various types of plants under different conditions. Hundreds of scientific tests are now under way and more are planned, with a view to simplifying the effective and safe use of 2,4-D as a weed killer.

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